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SYSTEMATIC REVIEW ON GASTROINTESTINAL HELMINTHS OF DOMESTIC RUMINANTS IN ETHIOPIA

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ABSTRACT: This systemic review was conducted to identify, critically assess, and bring together available data from primary researches conducted so far on gastrointestinal (GI) helminthes of domestic ruminants in Ethiopia. In the country, GI helminths of domestic ruminants have been identified; examined and informative statistics has been extracted since a few decades ago. For this review, relevant articles were retrieved from English databases: PubMed, Google Scholar, Science Direct, Web of Science and Scientific Information Database (SID). Additional studies were recognized by scanning the African Journal Online (AJOL) that includes the Ethiopian Veterinary Journal and Bulletin of Animal Health and Production. Out of retrieved (n=154) articles, thirty three (n=37) articles which fulfilled the eligibility criteria were selected. Accordingly, twenty three GI helminthes species which belong to the three classes of helminthes have been found to occur in domestic ruminants in the country. The main genera reported so far are *Haemonchus*, Strongyloides, *Trichostrongylus*, *Oesophagostomum*, *Bunostomum*, *Fasciola*, *Monezia* and *Paramphistomum* whereas, *Haemochus contortus*, *Moneizia expansa* and *Fasciolahepatica* are the most frequently reported species from Nematode, Cestode and Trematode classes respectively. The overall GI helminths prevalence ranged from 2.3% to 100% were reported. Simple flotation, sedimentation, modified McMaster technique and faecal culture are the most common and routine diagnostic methods which have been used in the country. Management aspects like husbandry practices, climate and host influences are found to be the principal contributing factors that affect GI helminths infections. So far, the control of GI parasites in the country is mainly focusing on the use of anthelmintics. Consequently, due to the lack of effective control strategies, antihelmintics are exclusively used which result in antihelmintics resistance. Generally, occurrence, epidemiological features, realistic control strategies, common diagnostic procedures and frequently encountered species are reviewed. Finally, the relevance of epidemiological knowledge and the development of efficient, sustainable and conventional control measures which cover wider ago-climatic zones of the country are suggested for controlling GI helminths infections and should be assessed timely.

Keywords: Anthelmintics, Domestic ruminant, Ethiopia, Gastrointestinal helminthes.

INTRODUCTION

As a result of having different agro-ecological zones and favorable environmental situations in Ethiopia, the country is believed to be endowed numerous livestock species and suitable for livestock production. It has the largest livestock population in Africa (Tilahun and Schmidt, 2012; CSA, 2013). According to CSA (2013) report, an estimated statistics showed that about 54 million cattle, 25.5 million sheep and 24.06 million goats are found in the country. Of the total cattle population, 98.95% are local breeds and the remaining are hybrid and exotic breeds. Furthermore, 99.8% of the sheep and nearly all goat population of the country are local breeds (CSA, 2013).

However, diseases have numerous negative impacts on production and productivity. Among diverse animal diseases encountered in the country, helminthes infections remain one of the most important limiting factors and a bottlenecking production and productivity these days (Elsa et al., 2012). By chance, the gastrointestinal tract of ruminants harbors variety of parasites particularly helminthes which can cause both clinical and subclinical parasitism. As stated by Lebbie et al. (1994), GI helminthes infections are of a global concern for livestock industry, which have devastating impact in Sub-Saharan Africa in general and in Ethiopia in particular as a result of wider range of agro-ecological factors which are fitting for diversified hosts and parasite species. Hence, gastrointestinal (GI) helminthiasis has become among the most important diseases encountered by livestock sector of Ethiopia and has been considered to be one of the major constraints in the development of the sector (Regassa et al., 2006). In Ethiopia, helminthiasis is responsible for 25% mortality and 3.8% weight loss in highland sheep (Bekele et al., 1992).

According to Zahid et al. (2005), the helminthes infections of ruminants are mostly caused by nematodes like Strongyliodes spp., *Ostertagia* Spp., *Bunostomum* and Trichuris spp.; Cestodes such as *Moniezia* spp., *Taenia* spp. and Trematodes such as *Paramphistomum* spp., *Fasciola* spp. and *Shistosoma* spp. Perry et al. (2002) reported that GI nematodes have been ranked highest on globalindex with *Haemonchus contortus* on top. Moreover, Trichostrongyloidea that include genera such as *Haemonchus*, *Trichostrongylus*, *Cooperia*, and *Nematodirus*, and the Strongyloidea and Ancylostomatoidea with *Oesophagostomum* and *Bunostomum*, are the economically most important and widely prevalent GI nematodes (Takele et al., 2013; Winter et al., 2018). In addition, such a pervasive occurrence of the metacestodes; *Cysticercus ovis* and *Cysticercus tenuicollis*; Hydatid cyst (*E.granulosus*)*; Fasciola hepatic* and *Fasciola gigantic* are most prevalent in the country and considered to be of great economic importance (Lemma et al., 1985; Regassa et al., 2009; Nigatu et al., 2009; Kebede et al., 2009; Feyesa et al., 2010; Nigatu, 2010; Endale et al., 2013; Abebe et al., 2015; Beyene and Hiko, 2019).

There are many associated risk factors influencing the occurrence and epidemiology of GI helminthes including age, sex, weather condition and husbandry or management practices (Khan et al., 2009). Factors such as host age, physiological status, breed, parasite species involved, and the epidemiological patterns (husbandry practices and climate variables) determine the degree of infection (Tembely and Hansen, 1996; Menkir et al., 2007). In Ethiopia, several studies have been conducted on ruminant helminthiasis in various regions reporting a prevalence ranged from 2.3–100% (Fikru et al., 2006; Abebe and Esayas, 2001; Yirsaw and Zewdu, 2015).

A number of published research reports have been found on GI helminthes of domestic ruminants in Ethiopia. However, these reports are found in a separate and unorganized way. So, comprehensive and well organized documentation about GI helminthes of domestic ruminant in the country is essential to support researchers, professionals and policy-makers to develop further actions on the control and prevention strategies. Therefore, the aim of this systematic review was to identify, assess critically, and bring together available data from primary research conducted so far on gastrointestinal (GI) helminthes of domestic ruminants in Ethiopia.

MATERIALS and METHODS

Source, selection strategies and protocol

This systematic review was carried out on GI helminthes of Ethiopian ruminant using available electronic and non-electronic databases. The electronic search was used as the primary search method. The main electronic databases used were PubMed, Google Scholar, Science Direct, Web of Science, Scientific Information Database (SID) were accessed from University of Gondar, Ethiopia. Relevant studies have been identified from English databases in Pub Med, Google Scholar, Science Direct, Web of Science, Scientific Information Database (SID). Additional studies were recognized by scanning the African Journal Online (AJOL) that includes the Ethiopian Veterinary Journal and Bulletin of Animal Health and Production. Moreover, complete and congress articles like original descriptive studies (designated as cross-sectional study) in sheep, goats and cattle were also considered. Epidemiological parameters such as prevalence of GI helminthes infection among sheep, goat and cattle, and main contributing factors like age, sex, and geographical sub-regions of Ethiopia were considered thoroughly. An intensive data searching was made to collect available information (Figure 3). The searching strategies used were combining the phrases close to GI helminths in large and small ruminants in Ethiopia as indicated in Figure 1. Searches were restricted to peer-reviewed articles published nationally or internationally in English language.

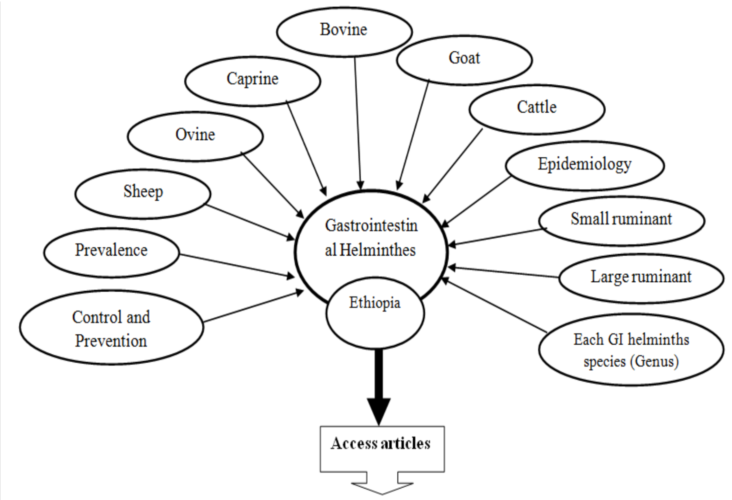

Figure 1 - A diagram showing a strategy for words combination to access relevant articles.

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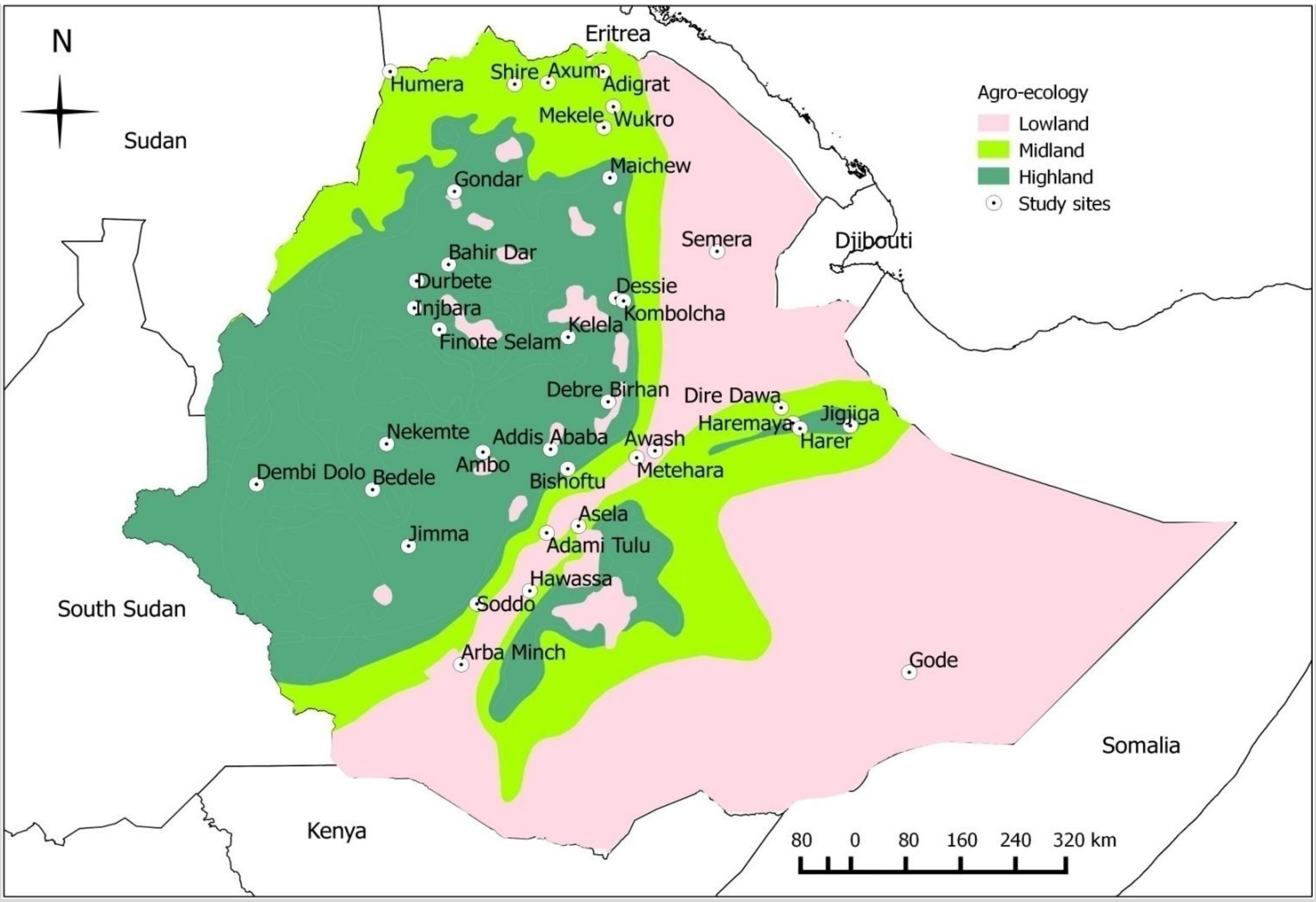

Figure 2- Map of Ethiopia showing study sites of GI helminthes of domestic ruminants.

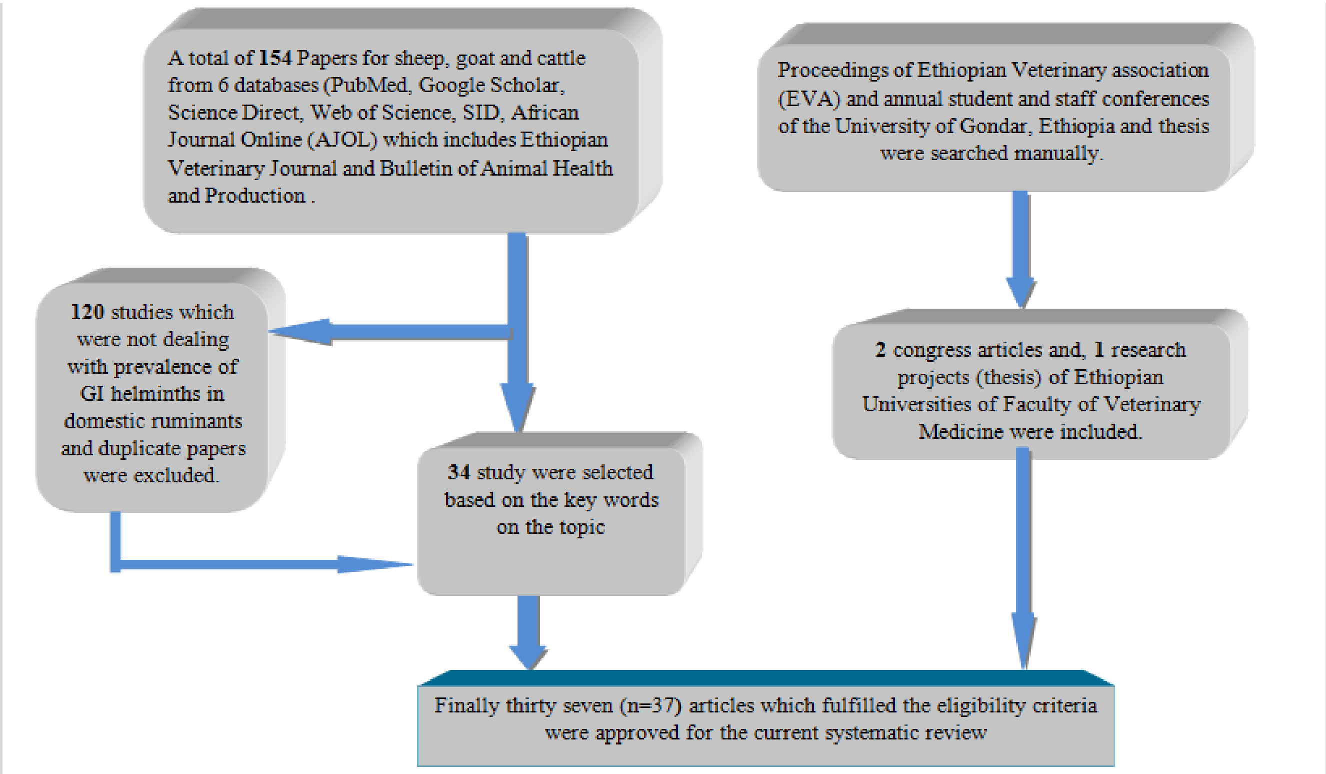

Figure 3 - Flow diagram describing the study design process and literature search on GI helminthes in domestic ruminants.

Data type and collecting methods

Published papers were scanned by quick reading to select relevant articles. Important articles were defined and included in the current review as one that contained information on GI helminthes of cattle, sheep and goat in Ethiopia. References of all relevant articles were searched to identify articles that were missed by the electronic search. Any

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identified article was subjected to the same inclusion process as a data type. Following that all relevant articles were reviewed, extracted and compiled in a searchable database (Microsoft Access software, ver. 2007). Extracted information included authors name, study sites, year of the study commenced and ended, year of publication, study design, species of animals, sampling procedure, number of animals selected, body condition, sex, altitude of the study site, laboratory procedure to detect the parasite, testing methodology and prevalence of GI helminthes reported including their associated risk factors.

Reports collected on GI helminths in Ethiopia

The initial electronic searches yielded a total of (n=154) studies. After scrutinizing these and eliminating duplicates, thirty three (n=37) were considered (Figure 4) including thesis containing relevant information concerning GI helminths of ruminants in Ethiopia. This review work documented that of the relevant articles about 8% (3) were not retrieved by any of the search engines, 19% (7) were retrieved by a single search engine, 27% (10) by two, 16% (6) by three and 30% (11) by all four databases. Providing a balanced and an impartial summary of the topic using these representative studies was at the core of this review. No restrictions other than identifying ovine, caprine and bovine GI helminthes in Ethiopia were imposed on the inclusion criteria. This minimized literature selection bias and provided an exhaustive list of GI helminths. However, for factors associated with domestic ruminant GI helminthes in Ethiopia, strict inclusion criteria were applied in order to only select the critical studies. In order for the current review to be critically appraised, repeatability was crucial. This was achieved by documenting every step of the review process.

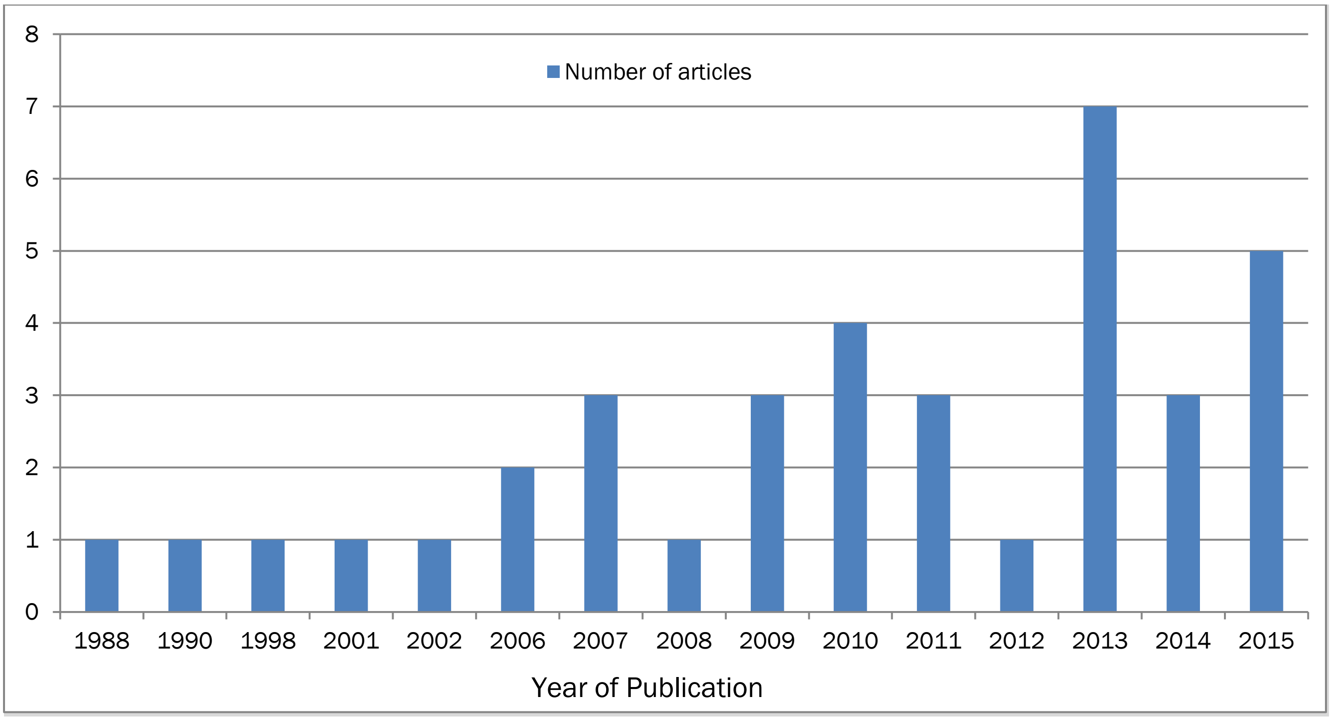

Figure 4 - Frequency of articles relevant to the systematic review on GI helminths of domestic ruminants in Ethiopia.

Occurrence and spatial distribution

The present review work revealed that the occurrences of GI helminthes infections were reported in different parts of the country (Figure 2). The prevalence of GI helminthes is summarized in table 1. The majority of the prevalence studies were specific on some helminthes genera like Strongyles, *Fasciola*, *Shistosoma* and some families like GI nematodes, Trematodes and Cestodes. However, adequate sources were not accessed compared to the number of studies done on specific species and families of the GI helminthes of domestic ruminants. In addition, most studies are based on the coprological examinations and few studies were conducted on abattoir surveys in the country.

According to the result obtained from the review, the overall prevalence of GI helminthes is ranged from 13.2% in Awash River Basin (Afar region) to 81.5% in Debre Zeit/Bishoftu (Bersissa et al., 2011; Moti et al., 2013). Furthermore, the review underlined that the majority of the identified species are found from nematodes and the lowest from Cestode. On the other hand, *Haemochuscontortus*, *Moneiziaexpansa* and *Fasciolahepatica* are the predominant species from Nematode, Cestode and Trematode classes respectively. Furthermore, *Nematodirus* spp., *Toxocaravitulorum* and *Schistosoma* spp. are less prevalent (Table 2). In Ethiopia the majority of the studies were focusing only on small ruminants' GI helminthes than large ruminants. Therefore, the highest prevalence of the parasite was reported from sheep (91.2%) in Gode (Ogaden), Southern Ethiopia than cattle (21.9%) in Nekemete in Western part of Ethiopia (Table 1). On the other hand, most Abattoir survey reports have also shown a status of GI helminths of cattle than small ruminants.

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Table 1 - List of selected studies on GI helminthes of domestic ruminants in Ethiopia

Study site(s)	Study animals and Sample size				Study period	ST	Diagnostic technique	Prevalence (%)				Sample	Author(year)
	Sheep	Goat	Cattle	Total				Sheep	Goat	Cattle	Total		
Adama	92	208	852	1152	Nov2007-Apr2008	CS	PME	29.3	6.7	46.8	-	Liver	Getawa et al. (2010)
Adami Tulu	-	499	-	499	Jul1997-Jun1998	CS	MM	-	45.5	-	45.5	F	Etana (2002)
Addis Ababa	560	-		560	Sep 1985 - Jun 1986	CS	PME	19.6	-	-	19.6	Liver	Bekele et al.(1988)
Ambo	90	30	-	120	Feb-May 2013	CS	DS,FL,SD	47.8	53.3	-	-	F	Temesgen and Walanso (2015)
Arba Minch	241+20	357+25	-	598 + 45	Jan2010-Aug 2011	CS	SD,FL, MM,PME	79.7; 85	63.6; 68	-	70.1;	F, GIT	Nejib et al. (2014)
Asella	-	-	384	384	Nov 2013-Apr 2014	CS	FL	-	-	49	49	F	Addisu and Berihu (2014)
Asella	408	-	-	408	Nov 2008-Apr 2009	CS	MMM	68.1	-	-	68.1	F	Diriba et al. (2013)
Awash	3,697	-	-	3,697	Jan-Dec 2005	CS	EAC	13.2	-	-	13.2	F	Ahmed et al.(2007)
Bahir Dar	340	-	420		May 2005 - Dec2006			10.6	-	34.05	-	Liver	Nigatu et al. (2009)
Bahir Dar	384	-	384	768	Nov2010-March 2011	CS	SD, PME	10.9; 16.9	- -	31.5; 45.3	-	F, Liver	Ayalew and Endalkachew (2013)
Bahir Dar	-	-	384	4134	Nov2008-March2009	CS	SD, PME	-	-	39.95	39.95	F, Liver	Fikirtemariam et al. (2013)
Bahir Dar	-	-	384	384	Nov2013-April 2014	CS	SD	32.3	-	-	32.3	F	Yitayal et al. (2015)
Bedele	-	-	500	500	Oct 2011-March 2012	CS	SD, FL, MM	-	-	64.2	64.2	F	Moti et al. (2013)
Bishoftu (Debre Zeit)	1152	1536	-	2688	Dec2005 - Jun 2006	CS	PME	58.5	43.8	-	-	Liver	Jibat et al. (2008)
Bishoftu (Debre Zeit)	157	65	-	222	Nov2007-Apr2008	CS	FL,SD, CC	81.0	83.0	-	81.5	F	Bersissa et al. (2011)
Bishoftu (Debre Zeit)	-	-	326	326	Nov2011-Apr 2012	CS	FL, SD,	-	-	61	61	F	Cheru et al. (2014)
Debre Berhan	2500	-	-	2500	1987	CS	SD,FL	18	-	-	18	F, PME	Njau et al.(1990)
Dembi Dolo	255	245	257	757	2003-2004	CS	DS, SD,FL, MM	75.3	84.1	50.2	69.6	F	Fikru et al.(2006)
Dessie	510	420	-	930	Nov2011-Mar 2012	CS	PME	21.04	27.61	-	-	OM, PE, Liver,MS	Abebe et al.(2015)
Dire Dawa	425	420	-	845	Nov2011-April 2012	CS	PME	22.8	26.4	-	24.6	Liver, PE OM	Endale et al. (2013)
Durbete	202-	-	330	532	Oct 2014- Apr 2015	CS	SD	2.3	-	24.6	26.9	F	Yirsaw and Zewdu (2015)
Gondar	458	100	-	558	Nov-Jan 2008	CS	SD, FL	46.07	55	-	47.67	F	Shimelis et al. (2011)
Gondar, Finote Selam, Injibara	-	-	22,755	22,755	Sept 2002-2007	CS	PME	-	-	79.5	79.5	Liver	Nigatu (2010)
Haremaya, Harar, Dire Dawa, Jijiga	655	632	-	1,287	May 2003-Apr 2005	CS	PME				-	GIT	Menkir et al. (2007)
Hawassa	284	226	-	510	Nov2008-Feb 2009	CS	MMM	47.2	38.9	-	-	F	Abebe et al. (2010)
Hawassa	-	-	632	632	Dec2008 – Mar 2009	CS	PME	-	-	52.6	52.6	Liver	Feyesa et al. (2010)
Hawassa	180	132	-	312	Jan-Jun 2006	CS	PME	91.1	87.1	-	-	A	Thomas et al. (2007)
Jimma	-	-	210	210	Nov2008-Apr 2009	CS	FL,SD, MMM	-	-	77.6	77.6	F	Hailu et al. (2011)
Kelala	230	-	154	384	Sept1997-Apr1998	CS	FL, SD	53	-	38	-	F	Tesfaye (1998)
Kombolcha	-	-	400	400	2011	CS	PME	-	-	17	17	Liver	Fufa et al. (2012)
Mekelle	-	-	1023	1023	Nov2007 - Feb2008	CS	PME	-	-	7. 23	7. 23	Liver	Getachew and Ashwani (2013)
Mekelle, Adigrat, Axum, Humera, Maichew, Shire	-	-	5,194	5,194	2007/8	CS	PME	-	-	22.1	22.1	Liver	Kebede et al. (2009)
Metehara, Semera, Jigjiga	92	91	-	183	Nov1998-Apr 1999	CS	MMM, PME	97.03	100	-	-	F , GIT	Abebe and Esayas(2001)
Nekemete	-	-	384	384	Nov2011-March 2012	CS	PME	-	-	21.9	21.9	GIT	Alula et al. (2013)
Ogaden-Gode	114	82	-	196	Aug2003-March 2004	CS	PME	91.2	82.9	-	-	A	Kumsa and Wossene (2006)
Wolaita Soddo	-	-	415	415	Nov2007 - Apr2008	CS	PME	-	-	11.3	-	Liver	Regassa et al. (2009)
Wukro	384	-	-	384	Nov 2013-Apr 2014	CS	PME	40.9	-	-	40.9	A	Lidya and Berihun (2015)

-: No information available; ST=Study design; PME=Postmortem examination; CS=Cross sectional; SD=Sedimentation, FL=Flotation, MM=Mc Master; DS=Direct Smear; MMM=Modified Mc Master; F= Faeces; A=Abomasum; GIT=Gastrointestinal content; EAC= Ethyl-acetate Centrifugation; PE=peritoneum; OM=Omentum; MS=Mesentry; RT= Retrospective

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Table 2 - GI helminthes species/genus composition; collected from each selected studies in Ethiopia.

Species of parasite identified (%)												Location	Altitude of study area	Author (year)
Nematode	Species of animal			Cestode	Species of animal			Trematode	Species of animal					
	Sheep	Goat	Cattle		Sheep	Goat	Cattle		Sheep	Goat	Cattle			
-	-	-	852	Hydatid cyst	40.0	55.6	37.1	-	-	-	-	Adama	1770	Getaw et al. (2010)
H.contortus Strongyloidesspp. *Trichostrongylus* spp. Trichuris spp. *Nematodirus* spp *Chabertia ovina* *Bunostomum* spp.	- - - - - - -	30.3 16.4 13.8 2.2 2.8 5.0 5.4	- - - - - - -	*M. expansa* *M. benedeni*	- -	14.6 4.0	- -	- -	- -	- -	- -	Adami Tulu	900	Etana (2002)
-	-	-	-	*T.hydatigena and Hydatid cyst*	18.6	-	-	-	-	-		Addis Ababa	2,326	Bekele et al. (1988)
Strongyles spp.	47.8	53.3	-	-	-	-	-	*Fasciola* spp.	4.4	6.7	-	Ambo	2185	Temesgen and Walanso (2015)
H.contortus *Trichostrongylus* spp. Teladorsagia spp. *T.colubriformis* *Haemonchus* spp.	A* A* A* A* A*	A* A* A* A* A*	- - - - -	- - - - -								Arba Minch	1400	Nejib et al. (2016)
*Ostertagia*spp *Oesophagostomum*sp Strongloid spp. Trychostrongylusspp Hemonchusspp. *Bunostomum* spp.	- - - - - -	- - - - - -	1.8 1.3 2.6 3.6 11.7 4.4									Assela	1500-2300	Addisu and Berihu (2014)
Strongylesspp Strongyloidesspp Trichurisspp	64.0 7.4 3.7	- - -	- - -									Asella	2500-3000	Diriba et al. (2013)
-	-	-	-	-	-	-	-	*Fasciola* spp.	13.2%	-	-	Awash	550-850	Ahmed et al. (2007)
-	-	-	-	*E. granulosus*	25.0	-	16.1	-	-	-	-	Bahir Dar	1784	Nigatu et al. (2009)
-	-	-	-	-	-	-	-	*F. hepatica* and *F.gigantica*	16.9	-	45.31	Bahir Dar	1784	Ayalew and Endalkachew (2013)
-	-	-	-	-	-	-	-	*F.hepatica* *F.gigantic* Mixed	- - -	- - -	89.7 3.63 6.67	Bahir Dar	1784	Fikirtemariam et al. (2013)
-	-	-	-	-	-	-	-	*F. hepatica*	-	-	32.3	Bahir Dar	1784	Yitayal et al. (2015)
Trichuris spp. Trichostrongyles spp.	- -	- -	6 .8 11.0	- -	- -	- -	- -	*Fasciola* spp Paramphistomu spp,	- -	- -	51.4 18.7	Bedele	2060	Moti et al. (2013)
-	-	-	-	*St.hepatica* *C.tenuicollis*	9.5 5.2	12.1 8.3	- -	*Fasciola* spp.	6.9	3.6	-	Bishoftu	2155	Jibat et al. (2008)
Strongyle type Strongyloides spp.	56.60 8.2	61.0 15.4	- -	M.expansa	13	29.2	-	*Fasciola*spp.	0.63	0	-	Bishoftu	2155	Bersissa et al. (2011)

Trichuris spp.	5.0	0.0	-											
Strongyle spp. Trichuris spp. *Toxocara* spp. Trichuris spp.	- - - -	- - - -	41.4 41.4 5.2 5.2	*Monezia* spp.	-	-	2.8	*Fasciola* spp. *Paramphistomum* spp.	- -	- -	36.5 18.4	Bishoftu	2155	Cheru et al. (2014)
Trichuris ovis *T, axei* *H. contortus* *Ostertagia* spp.	25.4 19.4 2.9 1.5	- - - -	- - - -	*C. ovis* *Moniezia* spp.	11.9 7.5	- -	- -	*Fasciola hepatica*	4.5%	-	-	Debre Berhan	2500-300	Njau et al. (1990)
Ascaris spp. Strongyle spp. Dictyocaulus spp. Trichuris spp.	1.6 70.2 4.3 4.5	2.5 78.4 1.2 9.8	2.8 47 0.4 1.6	-				*Fasciola* spp.	0	0	0.4	Dembi Dolo	1500-2000	Fikru et al. (2006)
-	-	-	-	*C.tenuicollis*, *C.ovis* Hydatid cysts	45.69, 8.43 9.02	72.38, 8.57 1.90	- - -	-	-	-	-	Dessie	2,400	Abebe et al. (2015)
-	-	-	-	*C.tenuicollis*	22.8	26.4	-	-	-	-	-	Dire Dawa	1204	Endale et al. (2013)
Shistisoma spp.	2.3	-	24.6	-	-	-	-	-	-	-	-	Durbete	1600	Yirsaw and Zewdu (2015)
Strongyle spp. Trichuris spp.	34.06 4.8	54 3	- -	*Monezia* Spp.	3.93	0	-	*F. hepatica* *Paramphistomum* *spp.*	8.52 0.87	6.99 0	- -	Gondar	1500-2000	Shimelis et al. (2011)
-	-	-	-	Hydatid cysts	-	-	38.8	-	-	-	-	Gondar, Finote Selam, Injibara	1917-2560	Nigatu (2010)
H.contortus. *T.axei* *T.vitrinus* *Trichostrongylus* spp. *Nematodirus spathir* *Cooperia curticei* Strongyloides spp. *Bunostomum* spp *Oes.columbianum* *Oesophagostomum* *Chabertia ovina* Trichuris spp	A* A* A* A* A* A* A* A* A* A* A* A*	A* A* A* A* A* A* A* A* A* A* A* A*	- - - - - - - - - - - -	*M. expansa* *Av.centripunctata* *St.globipunctata* *St.hepatica* *Cysticercus ovis)* *C.tenuicollis* *E. granulosus* (cysts)	61 20 24 39 26 79 68	53 21 27 36 22 53 65		*P.microbothrium* *F.hepatica* *F. gigantica* *Dicrocoelium dendriticum*	25 26 20 7	21 3 10 2		Haremaya, Harar, Dire Dawa, Jijiga	2000	Menkir et al. (2007)
Haemonchus spp. *Trichostrongylus* spp. *Oesophagostomum* Trichuris spp. *Bunostomum* spp.	51.6 38.7 22.6 27.6 9.7	64.7 41.2 23.5 12.5 11.8										Hawassa	1790	Abebe et al. (2010)
-	-	-	-	Hydatid cysts	-	-	6.9	6.9	-	-		Hawassa	1790	Feyesa et al. (2010)
Haemonchus spp. *T.axei* Teladorsagia spp.	81.1 47.2 19.4	76.5 39.4 20.5	- - -									Hawassa	1790	Thomas et al. (2007)

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Strongyels spp. Strongyloid spp. Trichuris spp. Ascaris spp. Capillaria spp. *Nematodirus* spp.	- - - - - -	- - - - - -	32.4 3.3 1.9 2.4 1.4 0.9	M. expansa	-	-	5.2	*Fasciola* spp. *Paramphistomum*	- -	- -	23.3 48.6	Jimma	1750	Hailu et al. (2011)
Strongyles spp. Trichuris spp. Strongyloides spp. *Nematodirus* spp.	27.58 2.95 3.20 0.49	- - - -	3.6 0.74 0.6 5.3	*Moniezia* sp.	4.18	-	0.4	*F. hepatica*	1.47	-	4.8	Kelala,	1580	Tesfaye (1998)
-	-	-	-	Hydatid cysts	-	-	4.25	-	-	-	-	Kombolcha	500 - 1840	Fufa et al. (2012)
-	-	-	-	*Cysticercus bovis*	-	-	6. 74	-	-	-	-	Mekelle	2000-2200	Getachew and Ashwani (2013)
-	-	-	-	Hydatid cyst (*E.granulosus*)	-	-	8.1	-	-	-	-	Mekelle, Adigrat, Axum Humera, Maiche, Shire	1400 - 2500	Kebede et al. (2009)
Haemonchus spp. *T.axei* *T.colubriformis* *Bunostomum* spp. Strongyloides spp. Oesophagostomm. Trichuris spp.	90.82 55.8 87.15 38.97 38.02 74.8 51.75	96.5 64.3 90 35.2 43.6 70.8 48.18	-	*M.expansa* *C. tenuicolis* *Avitellina spp.* *Stilesia spp.*	27.6 32.8 33.7 31.6	20.6 34.0 35.1 28.8	- -	- -	- -	- -	- -	Metehara, Semera, Jigjiga	2300	Abebe and Esayas (2001)
-	-	-	-	-	-	-		*Fasciola* spp.	-	-	21.9	Nekemete	2,088	Alula et al.(2013)
Haemonchus spp. *Trichostrongylus* spp.	91.2 37.7	82.9 40.2	- -	- -	- -	- -	- -	- -	- -	- -	- -	Ogaden	1200	Kumsa and Wossene (2006)
-	-	-	-	*C. bovis* Hydatid cyst	- -	- -	0.0 9.9	-	-	-	-	Wolaita Soddo	2500	Regassa et al. (2009)
H.contortus	40.9	-	-	-	-	-	-	-	-	-	-	Wukro	1977	Lidya and Berihun (2015)

- : No information available, A*= no specific prevalence is mentioned

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Species composition and seasonal dynamics

In Ethiopia, the presence of GI helminthes infections in domestic ruminants is reported by many authors (Thomas et al., 2007; Menkir et al., 2007; Abebe et al., 2010; Shimelis et al. 2011; Diriba et al., 2013; Addisu and Berihu, 2014 and Cheru et al. 2014). According to the current review, about twenty three (23) GI helminthes species belonging to Nematode, Cestode and Trematode categories have been reported from infected cattle, sheep and goats (Table 2). Whereas, Menkir et al. (2007), Abebe et al. (2010), Hailu et al. (2011) and Shimelis et al. (2011) who reported that the most prevalent genera of GI helminthes were *Haemonchus*, Trichostronglyus. *Oesophagostomum*, *Nematodirus*, *Cooperia*, *Toxocara* and *Bunostomum* from Nematodes; *Monezia* and *Cyticercus*from Cestodes and *Fasciola*, *Paramphistomum* and *Shistosoma* from Trematode classes (Table 3).

Table 3 - Summary of Species compositions of GI helminthes of domesticated ruminants in Ethiopia.

Major Class	Species	Host	Predilection site(s)
Nematode	*Haemonchus contortus*	Cattle, sheep, goats	Abomasums
	Haemonchus placei	Cattle	Abomasums
	Ostertagia circumcincta	Cattle, Sheep, Goats	Abomasums
	Trichostrongylus axei	Cattle, Sheep, Goats	Small intestine
	Trichostrongylus colubriformis	Cattle, Sheep, Goats	Small intestine
	Cooperia curticei	Cattle, Sheep, Goats	Small intestine
	Strongyloides papillosus	Cattle, Sheep, Goats	Small intestine
	Ostertagia Spp.	Cattle, Sheep, Goats	Abomasum, Large intestine
	Chabertiaovina	Cattle, Sheep, Goats	Large intestine
	Oesophagostomum columbianum	Sheep, Goat	Large intestine
	Strongyloidespapillosus	Cattle, Sheep, Goats	Small intestine
	Trichuris ovis	Cattle, Sheep, Goats	Large intestine
	Nematodirus filicollis	Cattle, Sheep, Goats	Small intestine
	Nematodirus spathiger	Sheep	Small intestine
	Trichostrongylus vitrinus	Sheep, Goat	Small intestine
	Toxocara vitulorum	Cattle (calves)	Small intestine
Cestode	*Monezia expansa*	Sheep , Goat	Small intestine
	Cysticercustenuicollis (Taenia hydatigena)	Sheep , Goat	Omentum Mesenteries Peritoneum, Liver
	Ecchnoccocus granulossus	Sheep , Goat	Omentum Mesenteries Peritoneum, Liver
	Cysticercus ovis (Taenia ovis)	Sheep , Goat	Omentum Mesenteries Peritoneum, Liver
	Avitellina centripunctata (Av.centripunctata)	Sheep , Goat	Small intestine
	Stilesia globipunctata (St.globipunctata)	Sheep , Goat	Small intestine
	Stilesia hepatica (St. hepatica)	Sheep , Goat	Liver, biliary ducts
Trematode	*Fasciola hepatica*	Sheep , Goat Cattle	Liver
	Fasciola gigantica	Sheep , Goat Cattle	Liver
	Paramphistomum cervi	Sheep , Goat Cattle	Rumen
	Paramphistomum microbothrium	Sheep , Goat Cattle	Rumen
	Schistosoma bovis	Sheep , Goat Cattle	Liver, intestine, mesenteric lymph nodes and mesenteric veins

According to this systemic review, GI helminthiasis in domestic ruminants is severe and increasingly become an important focusing area of research in the country situation. A study conducted in western Oromia on GI parasites showed that Strangles were the most prevalent parasites encountered in the area (Moti et al., 2013). Similar study by Shimelis et al. (2011); Cheru et al. (2014), Nejib et al. (2016) and Diriba et al. (2013) reported that Strongyles were the most prevalent parasites encountered in North Gondar, Debre Zeit (East Shoa zone), Arbaminch (GamoGofa zone) and Asella respectively. As it has been reported by Abebe et al. (2015); Endale et al. (2013); Feyesa et al. (2010); Nigatu (2010); Kebede et al. (2009); Nigatu et al. (2009); Regassa et al. (2009); Jibat et al. (2008); Menkir et al. (2007); Bekele et al. (1988), metacestodes (larval cestodes) *Cysticercus* ovis (*Taeniaovis*), *Cysticercus tenuicollis* (*T. hydatigena*) and Hydatid cysts (*Echinococcus granulosus*) are the most prevalent species in Eastern Ethiopia. On the other hand, gastrointestinal infections as a result of adult cestodes such as *Avitellina centripunctata*, *Moniezia expansa* and *Stilesia globipunctata*, and bile duct infections with Stilesia hepatica were frequently reported in different parts of the country (Abebe and Esayas, 2001; Etana, 2002; Menkir et al., 2007; Bersissa et al., 2011). Nonetheless, a higher prevalence of strongyles infection was recorded in the midland and highland than the lowland, and in wet season than the dry season. The mean fecal egg count was found to be significantly higher in the midland area and in wet season (Nejib et al., 2016). However, according to a study by Abebe and Esayas (2001) in the arid and semiarid zones of Eastern Ethiopia revealed that during the dry seasons of the year, a greater prevalence rates of GI helminthes were recorded in sheep and goats, 95.6 % and 100 % respectively. Furthermore, according to an abattoir survey by Menkir et al. (2007) at 4 abattoirs located in the semi-arid zone of Eastern Ethiopia, the mean burdens of adult nematodes were generally moderate in both sheep and goats and showed patterns of seasonal abundance that corresponded with the bi-modal annual rainfall pattern, with highest burdens around the middle of the rainy season. There were significant differences in the mean worm burdens and abundance of the different nematode species between the four geographic locations, with worm burdens in the Haramaya and Harar areas greater than those observed in the Dire Dawa and Jijiga locations (Abebe and Esayas, 2001; Menkir et al., 2007; Abebe et al., 2010; Berssisa et al., 2011; Endale et al., 2013). The seasonality of the GI helminthes distribution is associated with the relative humidity and rainfall (Debela, 2002; Menkir, 2007). A number of reports throughout the country indicated that there are remarkable changes in faecal egg counts and prevalence of helminths infection as a result of seasonal variation and seasonal rainfall pattern (Fikru et al., 2006; Menkir et al., 2007; Takele et al., 2013). Furthermore, relatively higher GI Helminths egg counts were found in mid altitude and highland zones than in lowland due to the influence of existing fluctuations in geographic and climatic conditions between each zone (Demelash et al., 2006; Takele et al., 2013).

Epidemiological factors

The epidemiology of the GI helminthiasis relies on factors such as the infection pressure in the environment and the susceptibility of the host, species and pathogen factor (Tilahun, 1995). From epidemiological point of view, the infective stages which eventually become available to the host depend on the independent and interactive influences of several factors in the macro- and micro-environment (Urquhart et al., 1994; Woledemariam, 2005; Regassa et al., 2006; Takele et al., 2013). Parasitic, host and environmental factors are the most frequently reported determinants for the epidemiology of helminths (Etana, 2002; Fikru et al., 2006; Ahmed et al., 2007; Menkir, 2007; Shimelis et al., 2011; Yirsaw and Zewdu, 2015). As stated by Shimelis et al. (2011), the prevalence of helminthiasis at species level was about 46.07% and 55% in sheep and goats, respectively. Almost similar report was documented in and around Ambo town with the proportion of 47.8% and 53.3% in sheep and goats, correspondingly (Temesgen and Walanso, 2015). Among the collected articles, the highest post mortem examination result was reported in Eastern Ethiopia (100%) (Abebe and Esayas, 2001). Strong association between GI helminths and poor body condition was coupled with heavy intensity of infection in the majority of infected animals (Abebe et al., 2010; Diriba et al. 2013; Alula et al., 2013; Temesgen and Walanso, 2015). According to Abebe et al. (2010) and Cheru et al. (2014), the burden of GI parasites and total EPG was significant in different body conditions.

Host factor

Sex, age, breed, nutrition, physiological status and presence or absence of inters- infections aggravate the severity of infection (Demelash et al., 2006; Menkir et al., 2007).Clinical parasitic gastroenteritis has been reported in young animals whilst infections in mature animals are generally subclinical in nature (Thomas et al., 2007). The lower occurrence in adults has been attributed to immunological maturity as the animals grow and the increase in acquired resistance due to repeated exposure (Biffa et al., 2004). While, some local breeds are known to be genetically resistant to GIhelminths infections than others (Tibbo, 2006). In Ethiopia, the local sheep breeds (Washera, Farta, Afar, Menz, Horo); Goat breeds (Begait, Abewrgelie, Keffa,) and Cattle breeds (Boran , Fogera, Raya, Horro, Abigar, Shekko, Arssi) are relatively resistant to GI worms than exotic breeds (Frisch and O'Neill, 1998; Negussie et al., 2000; Tibbo, M. 2006; Menkir et al., 2007; Solomon et al., 2009; Kebede et al., 2012). In addition, Moti et al. (2013) reported that Physiological status of ruminants like level of host immunity to the parasites is subjected to the number of eggs produced by adult female helminthes. In the same way, the females are readily infected and existing worm burdens become more active and increase egg spassed in the feces and develop Larvae (L_3) on the pasture (Woldemariam, 2005).

Environmental factor

As far as Ethiopia is among the tropical African countries, the temperature is permanently favorable for larval development in the environment. The favorable environment for larvae development is ranged at temperature about 10–36 °C and humidity proportion of 85% (Debela, 2002). In the arid tropical climates of lowland areas of the country has an environment which ranges from extensive pasturelands and browse plants to intensive grazing areas (Nejib et al., 2016). This environment is ranged from harsh to favorable for growth and survival of free-living stages of the GI helminthes (Tilahun, 1995; Debela, 2002).

Pathogen factor

The epidemiology of GI helminthes is also strongly influenced by host-parasite biology after infection has been occurred (Abebe et al., 2010; Diriba et al., 2013). Hypobiosis has been undergone by GI helminthic the abomasal or intestinal mucosae of the host (Cheru et al., 2014). Whereas, Abebe and Esayas (2001) stated that the immune status of the host influenced the rates of hypobiosis and usually arrested during external environments are unfavorable for the development and survival of eggs and larvae. Such development cycle usually coincides with the onset of rainy seasons and favourable period for larval development and transmission (Kumsa and Wossenie, 2006; Feyisa et al., 2010; Hailu et al., 2011; Nejib et al., 2016).

Currently applied diagnostic techniques

The diagnosis of helminthes of ruminants is based on demonstrating the presence of eggs or larvae in fecal samples or parasites recovered from the digestive tracts or other viscera of the animals (Hailu et al., 2011; Addisu and Berihun, 2014). Although a great variety of methods and modifications have been described fordiagnosis, standardized techniques such as egg or larval counts, worm counts and pasture larval counts did not exist. Therefore, most diagnostic laboratories

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as well as teaching and research institutions were applied their own set of protocols and test procedures (Kassai, 1999). Common diagnostic procedures for helminthes infections in Africa in general and in Ethiopia in particular are simple flotation, sedimentation, modified McMaster and faecal culture methods (Hansen and Perry, 1994; Kassai, 1999; Waller, 1997). Some nematode genera such as strongyloides produce eggs that are identical in appearance which couldn't be identified easily by faecal examination alone. So to identify these faecal cultures are required (Hansen and Perry, 1994; Urquhart et al., 1996; Kassai, 1999; Van Wyket al., 2004). However, *Nematodirus*, Strongyloides and Trichurisspecies have eggs that can be differentiated by their distinctmorphological features. Post-mortem examinations and identification of adult worms and arrested larvae in animals are the definitive means of identifying the parasite. Similar to faecal egg counts; there are many procedures that are described for post-mortem examination for nematode parasites (Hansen and Perry, 1994; Urquhart et al., 1996; Kassai, 1999).

Chemotherapies and control options

Effective helminthic control is a major element in ensuring the sustainability of animal production. The main aim of control is therefore to ensure that the biotic potential of a parasite is restrained at a level compatible with the biological requirements of economic livestock production (Waller, 1997). Since eradication of gastrointestinal parasites is not practical, only integrated control methods can be envisaged. Some of the basic principles include grazing management, acquisition of natural or artificially induced immunity, biological control and the judicious use of anthelmintic (Hazelby et al., 1994).The main methods for control of helminthic parasites are prophylactic treatment with antihelmintics combined with grazing management (Van Wyk et al., 1999). Despite the accumulation of drugs in animal products and undesirable effects on non-target organisms in the environment, together with an increase in anthelmintic resistance, the use of antihelmintics still remains the corner-stone of helminth control (Waller, 1997; Van Wyk et al., 1999; Bersissa and Girma, 2009). Since animals are often infected with a wide range of helminths, the need for broad-spectrum compounds against trematodes, cestodes and nematodes, and their larval stages is obvious (Hazelbyet al., 1994). The epidemiological information on GI helminths parasites of domestic ruminants gathered in Ethiopia can be used to design appropriate control measures. In principle, control should aim at the reduction of transmission rates. Several control methods, which include cultural husbandry, chemical, biological, ethno-veterinary medicine and immunological control, have been proposed (Nejib et al., 2016).

Husbandry pattern, control and prevention

A thorough husbandry practices such as controlling stocking rates, rotational grazing, and providing hygienic grazing can be considered as an alternative husbandry control technique (Diriba and Birhanu, 2013; Abebe et al., 2015; Temesegen and Walanso, 2015). The best way to prevent GI helminthes is to keep animals away from potentially dangerous environment. An absolute separation of stock from intermediate host zone is only practical in intensive farming husbandry systems (Woldemariam, 2005) which the country has a limited effort to do so. However, in communal grazing condition which is very common and traditional in Ethiopia, animals are communally grazed and therefore; practices such as rotational grazing and provision of clean pastures would not be feasible (Menkir et al., 2007; Cheru et al., 2014).

Chemotherapeutic interventions

Nowadays, the control of GI parasites of livestock in Ethiopia is mainly based on the use of anthelmintics. The most commonly used generic broad spectrum antihelminthics that are available in Ethiopia are the Benzimidazoles, Imidazothiazoles and Macrocyclic lactones which consist albendazole, levamisole and ivermectin, respectively (Woldemariam, 2005; Kumsa, and Wossene, 2006; Menkir et al., 2007). It is readily available wherever in the country since it has been imported massively by the government and non-government institutions; and used by every individual including farmer. However, the use of antihelmintics at regular intervals for a long period of time and treating by mass whenever an animal manifest clinical syndrome has become the major issue for the development of multiple resistances; for instance against benzimidazoles (Woldemariam, 2005). Targeted or selective application of anthelmintic treatment might be an important tool to keep susceptible GI nematode strains in livestock and to delay this case. An alternative approach for selective anthelmintic treatment was studied using experimental small ruminants for the management of haemonchosis by using the FAMACHA© method in the Mid-Rift Valley of Ethiopia by Woldemariam (2005) and Menkir (2007). Such system can be used by the farmers themselves by checking their animals for signs of anaemia (VanWyketal, 2004). Unfortunately, it was not practiced very well in Ethiopia where mixed parasitc infection, and where traditional feeding practice is followed (VanWyk et al., 2004; Kumsa and Wossene, 2006). A cost-effective preventive control programs for helminth infection in ruminants is based on sound epidemiological knowledge of the time relationship between contamination of pastures and the seasonal availability of infective larvae in a given geographic area. Epidemiological knowledge, its application in grazing management whenever feasible and access to antihelmintics of high efficacy are key factors for the success of controlling helminth infections in domestic ruminants (Aynalem et al., 2009; VanWykand Mayhew, 2013). Projecting models derived from more complete information on the ecology of GI helminth infection and anthelmintic resistance, climate and local management factors provide a basis for improved control schemes based on chemotherapy, management and immunization within similar climate (VanWyk and Mayhew, 2003; Woldemariam, 2005; Menkir et al, 2007).

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Ethno-veterinary practices

As a result of the gradually increasing anthelmintic resistance, residual effect on animal products, environmental pollution, scarcity and high cost of such drug especially to poor farmers have enforced to reconsider other alternative helminthic control technique in the country (Bersissa and Girma, 2009). Of these, Ethno-veterinary medicine has become a substantial and most expanding interest of options for Ethiopian farmers. Although such a kind of conventional veterinary medical system was yet very poor in the country, a very limited effort have been done to encourage the widely used ethno-veterinary plants in the country (Lulekal et al., 2008; Fullas, 2010; Asfaw and Fentahun, 2020). In order to do so, several Ethno-veterinary surveys were conducted so far in the country which indicated as if several traditional healers use medicinal plants for de-worming livestock (Jemal et al., 2011). To mention few examples, Herbal preparations from fresh leaves of *Dodonea viscose*, *Albizia gummifera* and *Vernonia amygdalina* against mixed natural infections in sheep was evaluated by Biffa et al. (2004) to show the anthelmintic activities. In addition, an In-vitro antihelmintics activity study from *Rhus glutinnosa*, *Syzygium guineensa*, *Albizia gummifera*, *Croton macrostachyus*, *Ekebergia capensis, Acacia nilotica and Terminalia schimperiana* against *Haemonchis contortus* have been reported by Eguale et al. (2006) and Jemal et al. (2011). Furthermore, anthelmintic activity of plants such as *Allium sativum, Zingiber officinale, Cucurbita mexicana, Ficus religiosa, Artemisia brevifolia, Calotropis procera, Nicotiana tabacum, Butea monosperma*, *Coriandrum sativum*, *Ocimum*, *Thymus schimperi* and *Echinops kebericho* have been reported by Abera (2003), Biffa et al. (2004) and Giday et al. (2007).

CONCLUSION

This review work assessed the GI helminthes in Ethiopia and provides a clue on perspectives and constraints encountered in researches which were done on GI helminths in ruminants. Twenty three (23) GI helminthes species that belong to all the three major classes of helminths have been found to occur in domestic ruminants in Ethiopia. In addition, nematodes are the most commonly encountered GI helminths while Cestodes are the least. In most reports, a higher rate was recorded in small ruminants. The most prevalent genera of GI helminths reported in order of prevalence are *Haemonchus*, Trichostronglyus, *Oesophagostomum*, *Nematodirus*, *Cooperia*, *Toxocara* and *Bunostomum* from Nematodes; *Monezia*and *Cyticercus* from Cestodes. Whereas, *Fasciola*, *Paramphistomum* and *Shistosoma* are found from Trematode category. Both the abattoir and coprological studies have indicated that infection by GI helminthes in ruminants is highly prevalent and widespread in all agro-ecologies and livestock production systems in Ethiopia. Fecal diagnostic techniques such as simple flotation, sedimentation, modified McMaster have been used routinely in Ethiopia. It has been also shown that prevalence of GI helminthes parasites was related to the agro-climatic conditions such as quantity and quality of pasture, temperature, humidity and grazing behavior of the host and the susceptibility of any intestinal helminthic parasites were also influenced by age, breed, species, health status, physiological factors and previous exposure to parasites.

Due to the lack of effective helminthes control strategies in Ethiopia, antihelmintics are exclusively used. Though Ethiopia has a huge amount of small and large ruminants population, the country is facing a direct and indirect economic lose as a result of GI helminthes infection. Hence, immediate remedies shall be taken into action on control and prevention methods against such anthelmintic resistant GI parasites. In order to this, it is advantageous to collect and looking over the previous researches done so far to reconsider their gaps for the future short and long term actions on prevention and control strategies. So, all-inclusive and well organized documentation about GI helminthes of ruminants in the country is essential to support researchers and policy makers to develop such remedies. Finally, applicable field diagnostic technique should be introduced as far as mixed parasitic infection and traditional feeding practice is common in the country which can aggravate GI helminthes infection.

DECLARATIONS

Consent to publish

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Availability of data and materials

Data will be made available up on request of the primary author

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